METHOD AND APPARATUS FOR SENSING, STORING, AND GRAPHICALLY DISPLAYING OVER-TEMPERATURE CONDITIONS OF JET ENGINES

BACKGROUND OF THE INVENTION

The present invention relates in general to methods and devices for indicating temperatures, and more particularly for indicating and recording excessive temperature conditions of jet engines.

Because of the deleterious effect of excessive temperature conditions on turbine jet engines, the frequency of inspection and maintenance of the engines is to a large extent determined by the history of over-temperature conditions incurred by each engine. Typically, the most significant engine temperatures are the temperatures of the gasses at the inlet and outlet of the turbine and the temperatures of the turbine blades and inlet guide vanes. Accordingly, it is one or more of these temperatures which is usually monitored. If a particular engine has incurred a predetermined number of over-temperature events, then the engine manufacturer specifies that an inspection of the "hot" section of the engine shall be performed. If no visual distress is found, the engine may continue in service for a specified period of time, after which the engine must be replaced and overhauled. Of course, if visual distress is located during the inspection, then the engine must be replaced at that time.

In general, the number of over-temperatures allowed before mandatory inspection and/or replacement has been heretofore established without regard to the time duration during which the engine operated at the excessive temperature. However, the likelihood of damage or distress to the engine is a function not merely of the over-temperature, but also of the magnitude and time duration of the over-temperature. In other words, an engine which has incurred a total of ten over-temperature events, each being for a relatively short time duration, is less likely to have incurred dangerous distress as an engine which has been subjected to five over-temperature conditions, each of excessive time duration. Accordingly, the severity of the over-temperature condition is most reliably and accurately determined by monitoring both the magnitude and the duration of the exhaust gas overtemperature.

In the past, flight instruments for monitoring the "hot" sections of the engines have not been capable of accurately recording the temperature versus time characteristics of the over-temperature event. This is particularly so where the flight engineer is required to monitor and record the duration of the excessive temperature incident. In many instances, particularly where an engine has entered a compressor stall condition, the flight deck engine instruments may not be monitored closely enough to accurately determine the time versus temperature parameters of an over-temperature occurrence. Any uncertainty as to the severity of the over-temperature event may lead to unnecessary and costly maintenance action, by erring on the side of safety, or worse, failure to perform timely maintenance. It is thus extremely important to accurately monitor and record every over-temperature condition and it would be desirable to record the precise temperature magnitude versus time duration characteristics of the event. Knowledge of the peak temperature reached and the length of time the engine temperature was above the over-temperature threshold are critical factors in safe and yet economically efficient determination as to the frequency of engine inspections and overhauling.

In addition to the absence of an accurate recording of the temperature versus time characteristics of an over-temperature event, flight deck instruments, heretofore, have not presented the temperature versus time information in a manner which is easily, quickly read and assimilated by the flight engineer. In some cases, the temperature event may be so excessive and so severe, that instantaneous notice of the event to the flight crew is critical. Merely providing a temperature indication which must be watched over a time interval of several seconds, does not provide a reliable interface between the instrument and the operator.

SUMMARY OF THE INVENTION AND ITS OBJECTIVES

Accordingly, it is an object of the present invention to provide method and apparatus for automatically sensing, displaying, and recording one or more over-temperature events exhibited by a jet engine in a manner which overcomes the foregoing disadvantages of prior instruments.

It is another object of the present invention to provide a compact, electronically energized, graphical display of the temperature versus time characteristics of each such over-temperature event.

Still a further object of the present invention is to provide a light emitting diode matrix display of such graphical information.

Additionally, it is an object of the present invention to provide a compact, electronically energized, solid state graphical display of a jet engine over-temperature condition in which the graphical information is presented in a format which instantaneously informs the operator of the temperature versus time severity of the event.

Also it is an object of the present invention to automatically, electronically record each of a plurality of over-temperature events, for subsequent retrieval and graphical display of the magnitude of temperature versus time for each such event.

Briefly, these objects are achieved in the preferred embodiments of the invention disclosed herein by a light emitting diode (LED) matrix controlled by electronic timing and digital storage circuitry which receives and processes an electrical signal representing the magnitude of a salient engine temperature, such as the turbine inlet or exhaust gas temperature. This circuitry detects the commencement of an over-temperature condition and begins to digitally store the instantaneous temperature magnitude at each of a plurality of succeeding time intervals. This digitally stored temperature versus time information is thereupon graphically presented by selectively energizing the appropriate rows and columns of the LED matrix. In the disclosed embodiments herein, the temperature is displayed on the vertical axis of the matrix while time is represented along the horizontal axis.

It is a feature of this indicator that the LED matrix is energized so as to light up all of the matrix diodes lying under the temperature versus time profile so that a histogramlike graph of the information is presented. Accordingly, the intensity of the LED display, that is the number of diodes energized, is a function of the severity of the temperature versus time characteristics